Attorney Docket No. 35392/41489
PATENT

SEP 25 2003

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

SPECIFICATION

INVENTION: **ABSORBER ELEMENT FOR SOLAR HIGH-TEMPERATURE HEAT GENERATION, AND A METHOD FOR ITS PRODUCTION**

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ABSORBER ELEMENT FOR SOLAR HIGH-TEMPERATURE HEAT GENERATION, AND A METHOD FOR ITS PRODUCTION

Description

[0001] The invention relates to an absorber element for solar high-temperature heat generation, of the type mentioned in the precharacterizing clause of Claim 1. Absorber elements such as these are generally known. The invention also relates to a method for producing such an absorber element.

[0002] In solar-thermal power stations, the radiation energy from the sun is concentrated by means of mirror systems, preferably with readjustment, and is used for heating a heat carrier medium. In one generally known design, the heat carrier medium flows through long absorber tubes, which are arranged at the focus of parabolic groove collectors.

[0003] Instead of using reflecting systems, the radiation energy can also be concentrated by using refracting systems (convergent lenses). One example of a linearly optically concentrating system such as this is disclosed in US Patent Specification 4 287 881, dated 8 September 1981.

[0004] Solar collectors, in which the actual absorber is surrounded by elements which reflect the radiation back to it, are disclosed, for example, in French Patent Specification 555 420, US Patent Specifications 4 300 538, 4 440 155, 4 512 335 and German Publications 27 57 155 and 30 20 310.

[0005] One problem with solar high-temperature heat generation is the heat losses that result from radiation emitted by the absorber tube. Owing to the high temperature, these heat losses are considerable. In order to reduce the heat losses, it is generally known for the actual absorber tube to be arranged in an outer tube. Although this reduces the heat losses, they are, however, still sufficiently high that the efficiency of solar high-temperature heat generation remains well below the theoretically achievable level.

[0006] The object of the invention is thus to provide an absorber element for solar high-temperature heat generation, in which the heat losses are minimal. A further aim is to provide a simple method for producing an absorber element such as this.

[0007] According to the invention, this object is achieved by the absorber element described in Claim 1. Advantageous refinements of the absorber element according to the invention are specified in the dependent claims. Claim 13 describes one preferred method for producing the absorber element.

[0008] The reflector channel which, according to the invention, is arranged around the absorber reflects the long-wave thermal radiation, which is radiated from the absorber, back to it, and thus minimizes the radiation heat losses.

[0009] At least on the inner face which points towards the absorber, the reflector channel is preferably formed from a small number of essentially planar surfaces. The majority of the thermal radiation which the absorber emits over an angle range of 180° is largely reflected directly back to the absorber from the straight reflector channel walls, and is not lost by multiple reflection on curved reflector channel walls.

[00010] The opening gap or slit in the reflector channel runs on the focal line of the light focusing unit. The focal line lies on the centre axis of the outer tube. Since the solar rays are focused by the light focusing unit onto the centre axis of the outer tube, they strike the outer tube at right angles and are not refracted by it. The absorber with its absorber tube and curved absorber plates can thus be stationary and firmly mounted. The solar rays, which diverge after the centre axis, completely strike an absorber channel, which is formed by the absorber tube and the absorber plates. No sunlight therefore strikes the wall of the reflector channel, which is optimized to reflect heat rays from the absorber.

[00011] The solar rays thus effectively heat the heat carrier medium in the absorber tube, for example in order to produce steam. The compact shape of the absorber element according to the invention allows high-temperature steam to be produced with low losses in small units. Even in regions in which the sunlight is relatively weak, the use of small units for high-temperature heat generation is thus technically and financially of interest. The steam can be used with high efficiency in a circulating process for electricity generation. Solar generation can thus be used at a high temperature for heating purposes, even in winter.

[00012] The production method according to the invention allows a minimum opening gap to be produced in the reflector channel, while compensating for the manufacturing and assembly tolerances of the light focusing unit. This results in a gap geometry which is optimally matched to the respective structure. The manufacturing complexity for the light focusing unit and for the absorber unit is reduced, and the thermal losses during operation are minimized.

[00013] Embodiments of the invention will be explained in more detail in the following text using the drawing by way of example, in which:

[00014] Figure 1 shows a cross section through an absorber element;

[00015] Figure 2 shows the absorber element in an arrangement with groove reflectors;

[00016] Figure 3 shows the absorber element in an arrangement with convergent lenses.

[00017] Figure 1 shows a cross section through an absorber element for solar high-temperature heat generation. The solar rays 10 coming from the sun are focused by a linear light focusing unit 60 (which is shown in Figure 2) onto the centre line of an outer tube 20. The centre line of the outer tube 20 thus coincides with the focal line of the light focusing unit. The outer tube 20 is preferably composed of glass. In general, the outer tube 20 is composed of a translucent material, through which short-wave radiation passes well but long-wave thermal radiation does not pass well. These requirements are satisfied by glass.

[00018] There is a vacuum in the interior of the outer tube 20. The rays, which diverge again behind the focal line, strike an absorber 30 there, which is arranged eccentrically with respect to the centre axis of the outer tube 20. The absorber 30 has a high absorption capability on the irradiated face, and has a low emission capability on the opposite face, in order to absorb a large amount of solar radiation and to emit little thermal radiation.

[00019] The absorber 30 is fixed in the outer tube 20. The absorber 30 comprises an absorber tube 32, in which a heat carrier medium circulates, and absorber sheets or absorber plates 34 which are fitted to the absorber tube 32. The absorber sheets or absorber plates 34 are preferably welded to the absorber tube 32, in order to ensure good heat transmission from the absorber plates 34 to the absorber tube 32. The absorber plates 34 are curved such that the incident solar rays 10 are virtually completely received and absorbed. The high degree of absorption is achieved by multiple reflection and absorption processes for obliquely incident solar rays 10 along the curved surface on the inner face of the absorber plates 34.

[00020] The absorber 30 is surrounded by a reflector channel 40, which reflects the thermal radiation coming from the absorber 30 back to it. The surface of the reflector channel 40 has a low emission and absorption capability. The reflector channel 40 has an opening gap 42, through which the solar rays 10 enter the channel 40, on the focal line. Since the focal line runs in the opening gap 42, the opening gap 42 may be narrow. The heat losses through the opening gap 42 are thus small. Apart from the opening gap 42, the reflector channel 40 is closed all the way round.

[00021] On the inner face pointing towards the absorber 30, the reflector channel 40 is formed from a small number of essentially planar surfaces, in order to ensure that the thermal radiation originating from the absorber 30 is reflected back as directly as possible. In cross section, as can be seen in Figure 1, the reflector channel 40 thus represents a rectangular or trapezoidal structure, in which the face of the reflector channel 40 in which the focal line runs can be bent slightly inwards towards the absorber 30 in order to achieve an optimum radiation profile on precisely this focal line, that is to say on the opening gap 42.

[00022] On its inner face with this bend, the reflector channel 40 thus has five essentially planar surfaces, and without a bend it has four such surfaces.

[00023] The reflector channel 40 is preferably coaxially surrounded by a further, outer reflector channel 50, which has the same surface characteristics as the inner reflector channel 40 and is connected in an interlocking manner to it at a small number of points by means of poorly thermally conductive elements, composed, for example, of ceramic. The outer reflector channel 50 on the face which the light strikes has an opening gap 52 which runs parallel to the opening gap 42 in the inner reflector channel 40 and is somewhat broader than it, in order to avoid blocking the solar rays 10.

[00024] The statements which have been made with regard to the inner reflector channel 40 apply equally to the interior of the outer reflector channel 50, that is to say the inner face of the outer reflector channel 50, which points towards the absorber 30, as well, is formed by a small number of essentially planar surfaces. However, the outer reflector channel 50 is circular on the outside, and can be rotated together with the inner reflector channel 40 about the centre axis of the outer tube 20. The reflector channels 40, 50 are positioned in rotation via magnets which are arranged outside the outer tube 20, in order to match their position to the incidence of the light, depending on the time of day. The magnets are mounted on a holding structure, which is arranged such that it can rotate about the outer tube axis. The light focusing unit is also mounted on the holding structure. The holding structure is positioned in rotation by an electric motor or motors. An optoelectronic sensor which is rotated together with the holding structure controls the rotational positioning for readjustment to match the light incidence direction.

[00025] The reflector channels 40, 50 have the function of reflecting long-wave thermal radiation which is emitted from the absorber 30 back to it, and thus of minimizing the heat losses caused by radiation. Electrochemically plated metal surfaces are able to reflect the majority of long-wave radiation. The absorber tube 32 together with the absorber plates 34 which are mounted on it is arranged firmly in the outer tube 20 and is not involved in the positioning movements of the reflector channels 40, 50. The absorber plates 34 absorb the short-wave solar radiation and prevent the solar radiation from striking the inner reflector channel 40 directly, and being absorbed there.

[00026] Figure 2 shows the arrangement of the outer tube 20 with the absorber 30 on a light focusing unit 60 with sheet deflection mirrors 62 and a parabolic groove mirror 64. The mirrors 62, 64 are mounted on a holding structure such that they can rotate about the axis of the outer tube 20. The sheet deflection mirrors 62 are arranged in the longitudinal direction of the outer tube 20, and are rotatably mounted at an angle of 90° with respect to the outer tube 20. They deflect obliquely incident rays such that they are always incident at right angles to the incidence plane of the parabolic groove mirror 64. In consequence, the rays always enter the outer tube 20 through its wall at right angles, without any major reflection losses. The sheet deflection mirrors 62 are positioned in rotation by an electric motor or motors, and their positions are controlled as a function of the time of day.

[00027] Figure 3 shows an alternative arrangement of the outer tube 20 with the absorber 30 on a light focusing unit with a linear convergent lens 66. The convergent lens 66 is mounted on a holding structure such that it can rotate with respect to the outer tube axis. The focal line of the convergent lens 66 lies on the outer tube axis.

[00028] In the described absorber element, the opening gap 42, 52 of the reflector channel 40 or of the reflector channels 40, 50 lies on the focal line of the light focusing unit 60, and on the centre axis of the outer tube 20. Since the solar rays are always focused on the centre axis of the outer tube 20 by the light focusing unit 60 which is readjusted to match the sun, they pass through the outer tube 20 at right angles, and are not refracted there. The absorber tube 32 and the absorber plates 34 which are thermally connected to it form an absorber channel, which is mounted firmly. The solar rays, which diverge once again after the centre axis, all enter this absorber channel. The reflector channel 40 or the reflector channels 40, 50 is or are readjusted by external magnetic forces, for example, with the outer tube 20 being stationary.

[00029] The described arrangement can be used for solar high-pressure direct vaporization for electricity generation in small power stations.

[00030] Water is used as the heat carrier medium for this purpose. The water is heated in an absorber tube 32 of an absorber element which is used as a feed water heater, and is vaporized and superheated in two or more downstream elements, in order to produce superheated high-pressure steam. The elements are arranged geographically offset with respect to one another, so that the superheated steam enters the upper elements. Two or more elements are in each case combined to form a module. The elements which can rotate are accommodated in the holding structure for the module. The absorber tubes of all the elements are expediently of the same length. However, since the vaporization process requires more thermal power than that required to heat the feed water, two absorber elements connected in parallel are used as evaporators, and some of the heated feed water is supplied to each of them via a distributor. In a simple case, the distributor may have a throttle valve in each feed line of the two absorber elements which form the evaporator, in order to supply the same amount of feed water to both. If these two absorber elements are fitted at different geodetic heights, the distributor may also have an overflow container for the heated feed water, which contains two overflows which are separate but are located at the same height and above the two absorber tubes of the evaporator, and from which the feed water flows away in a corresponding manner to the two absorber tubes. Both absorber tubes thus receive the same amount of feed water, despite being at different geodetic heights. The steam from two or more modules is carried in a closed circuit, and is expanded in a process machine in order to generate electricity. The expanded steam is liquefied, with heat being emitted to the environment, and is fed back to the modules via a feed water pump.

[00031] In low-power systems, a reciprocating piston motor with stepped pistons can be used as the process machine. A multistage reciprocating piston motor can adapt itself well to changing load requirements. For higher power levels, steam turbines may be used, although they do not react as quickly to load changes owing to the changing energy supply.

[00032] The described absorber element can advantageously be produced by assembling the absorber element completely, but with at least the wall of the inner reflector channel 40 still not having an opening gap 42. Parallel laser light is then injected via the light focusing unit 60 and, focused in this way, burns out the opening gap 42 from the wall of the reflector channel 40. This method results in an opening gap which takes account of the manufacturing and assembly tolerances of the light focusing unit with reduced manufacturing effort. The minimal size of the opening gap minimizes the thermal losses.

[00033] The opening gap 52 in the wall of the outer reflector channel 50 can also be produced in the same way.